CLAIMS

We claim:

~~1. An apparatus for block coding of windows of digitally represented images comprising a chain of lattices of lapped transforms with dyadic rational lifting steps.~~

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1. ~~2.~~ An apparatus for coding, storing or transmitting, and decoding M x M sized blocks of digitally represented images, where M is an even number ~~a power of 2~~, comprising

   a. a forward transform comprising

      i. a base transform having M channels numbered 0 through M-1, half of said channel numbers being odd and half being even;

      ii. an equal normalization factor in each of the M channels selected to be dyadic-rational;

      iii. a full-scale butterfly implemented as a series of lifting steps with a first set of dyadic rational coefficients;

      iv. M/2 delay lines in the odd numbered channels;

      v. a full-scale butterfly implemented as a series of lifting steps with said first set of dyadic rational coefficients; and

      vi. a series of lifting steps in the odd numbered channels with a second specifically selected set of dyadic-rational coefficients;

   b. means for transmission or storage of the transform output coefficients; and

   c. an inverse transform comprising

i. M channels numbered 0 through M-1, half of said channel numbers being odd and half being even;

ii. a series of inverse lifting steps in the odd numbered channels with said second set of specifically selected dyadic-rational coefficients;

iii. a full-scale butterfly implemented as a series of lifting steps with said first set of specifically selected dyadic-rational coefficients;

iv. M/2 delay lines in the even numbered channels;

v. a full-scale butterfly implemented as a series of lifting steps with said first set of specifically selected dyadic-rational coefficients;

vi. an equal denormalization factor in each of the M channels specifically selected to be dyadic-rational; and

vii. a base inverse transform having M channels numbered 0 through M-1.

3. The apparatus of Claim 2 in which the normalizing factor takes the value 25/16 and simultaneously the denormalizing factor takes the value 16/25.

4. The apparatus of Claim 2 in which the normalizing factor takes the value 5/4 and simultaneously the denormalizing factor takes the value 4/5.

5. The apparatus of Claim 2 in which the first set of dyadic rational coefficients are all equal to 1.

6. The apparatus of Claim 2 in which the second set of dyadic rational coefficients are all equal to ½.

7. The apparatus of Claim 2 in which the base transform is any M x M invertible matrix of the

form of a linear phase filter and the inverse base transform is the inverse of said M x M invertible matrix.

~~8~~ 7. The apparatus of Claim ~~2~~ 1 in which the base transform is the forward M x M discrete cosine transform and the inverse base transform is the inverse M x M discrete cosine transform.

9. An apparatus for transforming M x M blocks of digital image intensities comprising lapped transforms with overlapping factor K and having butterfly structures and lifting steps to generate M-channel uniform linear phase perfect reconstruction filter banks.

10. The apparatus of Claim 9 in which K equals 2.

~~11~~ 8. An apparatus for coding, compressing, storing or transmitting, and decoding a block of M x M intensities from a digital image selected by an M x M window moving recursively over the image, comprising:

a. an M x M block transform comprising:

 i. an initial stage

 ii. a normalizing factor in each channel

b. a cascade comprising a plurality of dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising

 i. a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;

 ii. a bank of delay lines in a first group of M/2 alternating lines;

 iii. a second bank of butterfly lifting steps with unitary coefficients, and

iv. a bank of pairs of butterfly lifting steps with coefficients of 1/2 between M/2 -1 pairs of said M/2 alternating lines;

c. means for transmission or storage of the output coefficients of said M x M block transform; and

d. an inverse transform comprising

i. a cascade comprising a plurality of dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising

a) a bank of pairs of butterfly lifting steps with coefficients of 1/2 between said M/2 -1 pairs of said M/2 alternating lines;

b) a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;

c) a bank of delay lines in a second group of M/2 alternating lines; and

d) a second bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;

ii. a de-scaling bank; and

iii. an inverse initial stage.

~~12~~. A method of block coding windows of digitally represented images comprising successive steps of processing the output of each step through a following step in a chain of lattices of lapped transforms with dyadic rational lifting steps.

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9. ~~13~~. A method of coding, storing or transmitting, and decoding M x M sized blocks of digitally represented images, where M is ~~a power of 2~~ an even number, comprising

a. transmitting the original picture signals to a coder, which effects the steps of

   i. converting the signals with a base transform having M channels numbered 0 through M-1, half of said channel numbers being odd and half being even;

   ii. normalizing the output of the preceding step with a dyadic rational normalization factor in each of said M channels;

   iii. processing the output of the preceding step through two lifting steps with a first set of identical dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration;

   iv. transmitting the resulting coefficients through M/2 delay lines in the odd numbered channels;

   v. processing the output of the preceding step through two inverse lifting steps with the first set of dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration; and

   vi. applying two lifting steps with a second set of identical dyadic rational coefficients connecting each pair of adjacent odd numbered channels to the output of the preceding step;

b. transmitting or storing the transform output coefficients;

c. receiving the transform output coefficients in a decoder; and

d. processing the output coefficients in a decoder, comprising the steps of

i. receiving the coefficients in M channels numbered 0 through M-1, half of said channel numbers being odd and half being even;

ii. applying two inverse lifting steps with dyadic rational coefficients connecting each pair of adjacent odd numbered channels;

iii. applying two lifting steps with dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration;

iv. transmitting the result of the preceding step through M/2 delay lines in the even numbered channels;

v. applying two inverse lifting steps with dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration;

vi. denormalizing the result of the preceding step with a dyadic rational inverse normalization factor in each of said M channels; and

vii. processing the result of the preceding step through a base inverse transform having M channels numbered 0 through M-1.

10.

~~14~~. A method of coding, compressing, storing or transmitting, and decoding a block of M x M intensities from a digital image selected by an M x M window moving recursively over the image, comprising the steps of:

a. Processing the intensities in an M x M block coder comprising the steps of:

i. processing the intensities through an initial stage;

ii. scaling the result of the preceding step in each channel;

b. processing the result of the preceding step through a cascade comprising a plurality of

dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising

i. a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;

ii. a bank of delay lines in a first group of M/2 alternating lines;

iii. a second bank of butterfly lifting steps with unitary coefficients, and

iv. a bank of pairs of butterfly lifting steps with coefficients of 1/2 between M/2 -1 pairs of said M/2 alternating lines;

c. transmitting or storing the output coefficients of said M x M block coder;

d. receiving the output coefficients in a decoder; and

e. processing the output coefficients in the decoder, comprising the steps of

i. processing the output coefficients through a cascade comprising a plurality of dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising

a) a bank of pairs of butterfly lifting steps with coefficients of 1/2 between said M/2 -1 pairs of said M/2 alternating lines;

b) a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;

c) a bank of delay lines in a second group of M/2 alternating lines;

d) a second bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;

e) a de-scaling bank; and

f. processing the results of the preceding step in an inverse initial stage.

~~15. The apparatus of Claim 2, with any approximation of the special constants in this patent filing.~~

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